

## PATENT COOPERATION TREATY

341 119

PCT

NOTIFICATION CONCERNING  
DOCUMENT TRANSMITTED

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark  
Office  
(Box PCT)  
Crystal Plaza 2  
Washington, DC 20231  
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as designated Office

Date of mailing (day/month/year)

27 July 1999 (27.07.99)

International application No.

PCT/EP99/03660

International filing date (day/month/year)

27 May 1999 (27.05.99)

Applicant

QIAGEN GMBH et al

The International Bureau transmits herewith the following documents and number thereof:

\_\_\_\_\_ copy of the international application (Article 13(1),(2)(b))

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Aino Metcalfe

Telephone No.: (41-22) 338.83.38

## PATENT COOPERATION TREATY

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## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Assistant Commissioner for Patents  
United States Patent and Trademark  
Office  
Box PCT  
Washington, D.C.20231  
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year)

20 December 1999 (20.12.99)

International application No.

PCT/EP99/03660

Applicant's or agent's file reference

990605woMegn

International filing date (day/month/year)

27 May 1999 (27.05.99)

Priority date (day/month/year)

27 May 1998 (27.05.98)

Applicant

SAUER, Philippe et al

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

25 November 1999 (25.11.99)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO  
34, chemin des Colombettes  
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

J. Leitao

Telephone No.: (41-22) 338.83.38

## PCT REQUEST

1/5

990605woMegn

Original (for SUBMISSION) - printed on 26.05.1999 02:42:33 PM

0	For receiving Office use only	
0-1	International Application No.	
0-2	International Filing Date	
0-3	Name of receiving Office and "PCT International Application"	
0-4	Form - PCT/RO/101 PCT Request Prepared using	PCT-EASY Version 2.83 (updated 01.03.1999)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	European Patent Office (EPO) (RO/EP)
0-7	Applicant's or agent's file reference	990605woMegn
I	Title of invention	RAPID AND SIMPLE PROCESS FOR ISOLATION OF CIRCULAR NUCLEIC ACIDS
II	Applicant	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	QIAGEN GMBH
II-5	Address:	Max-Volmer-Straße 4 D-40724 Hilden Germany
II-6	State of nationality	DE
II-7	State of residence	DE
III-1	Applicant and/or inventor	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
III-1-4	Name (LAST, First)	SAUER, Philippe
III-1-5	Address:	Poststrasse 38 D-40721 Hilden Germany
III-1-6	State of nationality	DE
III-1-7	State of residence	DE
III-2	Applicant and/or inventor	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	KANG, Jie
III-2-5	Address:	Heinrich-Heine-Straße 49 D-40699 Erkrath Germany
III-2-6	State of nationality	DE
III-2-7	State of residence	DE

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## PCT REQUEST

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990605woMegn

IV-1	<b>Agent or common representative; or address for correspondence</b> The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
IV-1-1	Name (LAST, First)	MEYERS, Hans-Wilhelm
IV-1-2	Address:	Patentanwälte von Kreisler Selting Werner Postfach 10 22 41 D-50462 Köln Germany
IV-1-3	Telephone No.	0221 916520
IV-1-4	Facsimile No.	0221 134297
IV-1-5	e-mail	mail@dompatent.de
IV-2	<b>Additional agent(s)</b>	agent
IV-2-1	Name (LAST, First)	WERNER, Hans-Karsten
IV-2-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-2-3	Telephone No.	0221 916520
IV-2-4	Facsimile No.	0221 134297
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IV-3	<b>Additional agent(s)</b>	agent
IV-3-1	Name (LAST, First)	VON KREISLER, Alek
IV-3-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-3-3	Telephone No.	0221 916520
IV-3-4	Facsimile No.	0221 134297
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IV-4	<b>Additional agent(s)</b>	agent
IV-4-1	Name (LAST, First)	SELTING, Günther
IV-4-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-4-3	Telephone No.	0221 916520
IV-4-4	Facsimile No.	0221 134297
IV-4-5	e-mail	mail@dompatent.de
IV-5	<b>Additional agent(s)</b>	agent
IV-5-1	Name (LAST, First)	FUES, Johann
IV-5-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-5-3	Telephone No.	0221 916520
IV-5-4	Facsimile No.	0221 134297
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## PCT REQUEST

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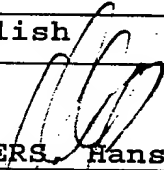
IV-6	Additional agent(s)	agent
IV-6-1	Name (LAST, First)	DALLMEYER, Georg
IV-6-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-6-3	Telephone No.	0221 916520
IV-6-4	Facsimile No.	0221 134297
IV-6-5	e-mail	mail@dompatent.de
IV-7	Additional agent(s)	agent
IV-7-1	Name (LAST, First)	HILLERINGMANN, Jochen
IV-7-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-7-3	Telephone No.	0221 916520
IV-7-4	Facsimile No.	0221 134297
IV-7-5	e-mail	mail@dompatent.de
IV-8	Additional agent(s)	agent
IV-8-1	Name (LAST, First)	JÖNSSON, Hans-Peter
IV-8-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-8-3	Telephone No.	0221 916520
IV-8-4	Facsimile No.	0221 134297
IV-8-5	e-mail	mail@dompatent.de
IV-9	Additional agent(s)	agent
IV-9-1	Name (LAST, First)	WEBER, Thomas
IV-9-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-9-3	Telephone No.	0221 916520
IV-9-4	Facsimile No.	0221 134297
IV-9-5	e-mail	mail@dompatent.de
IV-10	Additional agent(s)	agent
IV-10-1	Name (LAST, First)	HELBING, Jörg
IV-10-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
IV-10-3	Telephone No.	0221 916520
IV-10-4	Facsimile No.	0221 134297
IV-10-5	e-mail	mail@dompatent.de
V	Designation of States	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT

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990605woMegn

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V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	JP US	
V-5	<b>Precautionary Designation Statement</b> In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.		
V-6	Exclusion(s) from precautionary designations	NONE	
VI-1	Priority claim of earlier regional application		
VI-1-1	Filing date	27 May 1998 (27.05.1998)	
VI-1-2	Number	98109593.8	
VI-1-3	Regional Office	EP	
VI-2	Priority document request The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)	
VIII	Check list	number of sheets	electronic file(s) attached
VIII-1	Request	5	-
VIII-2	Description	24	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	abstract.txt
VIII-5	Drawings	0	-
VIII-7	TOTAL	33	
VIII-8	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-16	Fee calculation sheet	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-18	Figure of the drawings which should accompany the abstract		
VIII-19	Language of filing of the international application	English	
IX-1	Signature of applicant or agent		
IX-1-1	Name (LAST, First)	MEYERS, Hans-Wilhelm	

## FOR RECEIVING OFFICE USE ONLY

10-1	Date of actual receipt of the purported international application	
10-2	Drawings:	
10-2-1	Received	
10-2-2	Not received	

**PCT REQUEST**

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Original (for **SUBMISSION**) - printed on 26.05.1999 02:42:33 PM

10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

**FOR INTERNATIONAL BUREAU USE ONLY**

11-1	Date of receipt of the record copy by the International Bureau	
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**PCT (ANNEX - FEE CALCULATION SHEET)**

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(This sheet is not part of and does not count as a sheet of the international application)

0	<b>For receiving Office use only</b>	
0-1	International Application No.	
0-2	Date stamp of the receiving Office	
0-4	<b>Form - PCT/RO/101 (Annex)</b>	
0-4-1	PCT Fee Calculation Sheet Prepared using	PCT-EASY Version 2.83 (updated 01.03.1999)
0-9	Applicant's or agent's file reference	990605woMegn
2	Applicant	QIAGEN GMBH, et al.
12	Calculation of prescribed fees	
12-1	Transmittal fee T	⇒
12-2	Search fee S	⇒
12-3	International fee	
	Basic fee (first 30 sheets) b1	800
12-4	Remaining sheets	3
12-5	Additional amount (X)	19
12-6	Total additional amount b2	57
12-7	b1 + b2 = B	857
12-8	Designation fees	
	Number of designations contained in international application	3
12-9	Number of designation fees payable (maximum 10)	3
12-10	Amount of designation fee (X)	184
12-11	Total designation fees D	552
12-12	PCT-EASY fee reduction R	-246
12-13	Total International fee (B+D-R) I	⇒
12-14	Fee for priority document	
	Number of priority documents requested	1
12-15	Fee per document (X)	58,67
12-16	Total priority document fee P	⇒
12-17	TOTAL FEES PAYABLE (T+S+I+P)	⇒
12-19	Mode of payment	authorization to charge deposit account
12-20	Deposit account instructions	
	The receiving Office:	2800.0007 European Patent Office (EPO) (RO/EP)
12-20-1	is hereby authorized to charge the total fees indicated above to my deposit account	✓

**VALIDATION LOG AND REMARKS**

13-2-2	Validation messages States	Green? More designations could be made. Please verify.
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## PCT (ANNEX - FEE CALCULATION SHEET)

990605woMegn

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13-2-3	Validation messages Names	Green? Applicant 1.:Telephone No. missing
		Green? Applicant 1.:Facsimile No. missing
13-2-6	Validation messages Contents	Yellow! The power of attorney or a copy of the general power of attorney will need to be furnished unless all applicants sign the request form.
		Green? The international application contains no drawings. Please verify.
13-2-8	Validation messages Payment	Green? Please ensure that you have a valid deposit account with the receiving Office selected.
		Yellow The RO has been requested to furnish the priority document but has not been authorized to debit fees for such a request. Please verify.

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**PCT-EASY INFORMATION SHEET**

(For applicant use only, DO NOT submit this sheet with the international application)

**VALIDATION LOG**

	<b>States</b>
Green?	More designations could be made. Please verify.
	<b>Names</b>
Green?	Applicant 1.:Telephone No. missing
Green?	Applicant 1.:Facsimile No. missing
	<b>Contents</b>
Yellow!	The power of attorney or a copy of the general power of attorney will need to be furnished unless all applicants sign the request form.
Green?	The international application contains no drawings. Please verify.
	<b>Payment</b>
Green?	Please ensure that you have a valid deposit account with the receiving Office selected.
Yellow	The RO has been requested to furnish the priority document but has not been authorized to debit fees for such a request. Please verify.

Before submitting the International Application, please carefully verify that:

- the information contained on printed Request form is correct;
- Box IX of the Request form and item 12-22 of the Annex to the Request form have been signed;
- all elements of the international application as indicated in Box VIII of the Request form have been attached; and,
- the diskette containing the PCT-EASY zip file of the International Application has been enclosed and has been clearly labeled "PCT-EASY", with the applicant's or agent's file reference, and the first applicant's name.

**ATTENTION**

DO NOT modify any indications on the Request form printout. The attached PCT-EASY application has been locked. If an error or an omission is discovered at this time, you must copy the submitted application as a template and make the change or correction in a new application (using the submitted application as a template). You may create such a template by copying the submitted application from the "Stored Forms" folder to the "New PCT Forms" folder. Open the new (.OWO) file created in the "New PCT Forms" folder, correct the errors and proceed with the submission process again.

## PCT REQUEST

Original (for SUBMISSION) - printed on 26.05.1999 02:42:33 PM

990605woMegn

0	<b>For receiving Office use only</b>	
0-1	International Application No.	PCT/EP99 / 03 660
0-2	International Filing Date	27 MAY 1999 (27.05.99)
0-3	Name of receiving Office and "PCT International Application"	EUROPEAN PATENT OFFICE PCT INTERNATIONAL APPLICATION
0-4	<b>Form - PCT/RO/101 PCT Request</b>	
0-4-1	Prepared using	PCT-EASY Version 2.83 (updated 01.03.1999)
0-5	<b>Petition</b> The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	<b>Receiving Office (specified by the applicant)</b>	European Patent Office (EPO) (RO/EP)
0-7	<b>Applicant's or agent's file reference</b>	990605woMegn
I	<b>Title of invention</b>	RAPID AND SIMPLE PROCESS FOR ISOLATION OF CIRCULAR NUCLEIC ACIDS
II	<b>Applicant</b>	
II-1	This person is:	applicant only
II-2	Applicant for	all designated States except US
II-4	Name	QIAGEN GMBH
II-5	Address:	Max-Volmer-Straße 4 D-40724 Hilden Germany
II-6	State of nationality	DE
II-7	State of residence	DE
III-1	<b>Applicant and/or inventor</b>	
III-1-1	This person is:	applicant and inventor
III-1-2	Applicant for	US only
III-1-4	Name (LAST, First)	SAUER, Philippe
III-1-5	Address:	Poststrasse 38 D-40721 Hilden Germany
III-1-6	State of nationality	DE
III-1-7	State of residence	DE
III-2	<b>Applicant and/or inventor</b>	
III-2-1	This person is:	applicant and inventor
III-2-2	Applicant for	US only
III-2-4	Name (LAST, First)	KANG, Jie
III-2-5	Address:	Heinrich-Heine-Straße 49 D-40699 Erkrath Germany
III-2-6	State of nationality	DE
III-2-7	State of residence	DE

## PCT REQUEST

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Original (for SUBMISSION) - printed on 26.05.1999 02:42:33 PM

IV-1	<b>Agent or common representative; or address for correspondence</b> The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	<b>agent</b>
IV-1-1	Name (LAST, First)	MEYERS, Hans-Wilhelm
IV-1-2	Address:	<del>Patentanwälte</del> von Kreisler Selting Werner Postfach 10 22 41 D-50462 Köln Germany
IV-1-3	Telephone No.	0221 916520
IV-1-4	Facsimile No.	0221 134297
IV-1-5	e-mail	mail@dompatent.de
IV-2	<b>Additional agent(s)</b>	<b>agent</b>
IV-2-1	Name (LAST, First)	WERNER, Hans-Karsten
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IV-2-3	Telephone No.	0221 916520
IV-2-4	Facsimile No.	0221 134297
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IV-3	<b>Additional agent(s)</b>	<b>agent</b>
IV-3-1	Name (LAST, First)	VON KREISLER, Alek
IV-3-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
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IV-3-4	Facsimile No.	0221 134297
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IV-4	<b>Additional agent(s)</b>	<b>agent</b>
IV-4-1	Name (LAST, First)	SELTING, Günther
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IV-5	<b>Additional agent(s)</b>	<b>agent</b>
IV-5-1	Name (LAST, First)	FUES, Johann
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IV-5-3	Telephone No.	0221 916520
IV-5-4	Facsimile No.	0221 134297
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## PCT REQUEST

990605woMegn

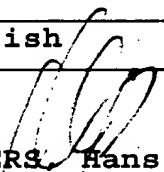
Original (for SUBMISSION) - printed on 26.05.1999 02:42:33 PM

<b>IV-6</b>	<b>Additional agent(s)</b>	<b>agent</b>
IV-6-1	Name (LAST, First)	DALLMEYER, Georg
IV-6-2	Address:	Postfach 10 22 41 D-50462 Köln Germany
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IV-6-4	Facsimile No.	0221 134297
IV-6-5	e-mail	mail@dompatent.de
<b>IV-7</b>	<b>Additional agent(s)</b>	<b>agent</b>
IV-7-1	Name (LAST, First)	HILLERINGMANN, Jochen
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IV-7-3	Telephone No.	0221 916520
IV-7-4	Facsimile No.	0221 134297
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<b>IV-8</b>	<b>Additional agent(s)</b>	<b>agent</b>
IV-8-1	Name (LAST, First)	JÖNSSON, Hans-Peter
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IV-8-5	e-mail	mail@dompatent.de
<b>IV-9</b>	<b>Additional agent(s)</b>	<b>agent</b>
IV-9-1	Name (LAST, First)	WEBER, Thomas
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IV-9-3	Telephone No.	0221 916520
IV-9-4	Facsimile No.	0221 134297
IV-9-5	e-mail	mail@dompatent.de
<b>IV-10</b>	<b>Additional agent(s)</b>	<b>agent</b>
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IV-10-4	Facsimile No.	0221 134297
IV-10-5	e-mail	mail@dompatent.de
<b>V</b>	<b>Designation of States</b>	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT

## PCT REQUEST

990605woMegn

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V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	JP US	
V-5	<b>Precautionary Designation Statement</b> In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.		
V-6	<b>Exclusion(s) from precautionary designations</b>	NONE	
VI-1	<b>Priority claim of earlier regional application</b>		
VI-1-1	Filing date	27 May 1998 (27.05.1998)	
VI-1-2	Number	98109593.8	
VI-1-3	Regional Office	EP	
VI-2	<b>Priority document request</b> The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1	
VII-1	<b>International Searching Authority Chosen</b>	European Patent Office (EPO) (ISA/EP)	
VIII	<b>Check list</b>	number of sheets	electronic file(s) attached
VIII-1	Request	5	-
VIII-2	Description	24	-
VIII-3	Claims	3	-
VIII-4	Abstract	1	abstract.txt
VIII-5	Drawings	0	-
VIII-7	TOTAL	33	
	<b>Accompanying items</b>	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-18	<b>Figure of the drawings which should accompany the abstract</b>		
VIII-19	<b>Language of filing of the international application</b>	English	
IX-1	<b>Signature of applicant or agent</b>		
IX-1-1	Name (LAST, First)	MEYERS Hans-Wilhelm	

## FOR RECEIVING OFFICE USE ONLY

10-1	Date of actual receipt of the purported international application	27.05.99	27.05.99
10-2	<b>Drawings:</b>		
10-2-1	Received		
10-2-2	Not received		

## PCT REQUEST

990605woMegn

Original (for SUBMISSION) - printed on 26.05.1999 02:42:33 PM

10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

## FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	01 JULY 1999 ( 01.07.99 )
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**Rapid and simple process for isolation of circular nucleic acids**

The invention is concerned with a method for separating circular nucleic acids from a mixture having different species of nucleic acids. Furthermore, an aqueous buffer for the method is disclosed.

Many techniques in molecular biology require pure nucleic acids in general and plasmid DNA in particular.

Plasmids are double stranded circular closed DNA molecules which are found in certain organism additional to chromosomal DNA. Examples for such organism are some yeast and plant cells and all species of bacteria. While chromosomal DNA comprises all the information necessary for the cells to live, natural occurring plasmids are an additional genetic element providing an advantage to the host cell under certain environmental conditions.

Plasmids are a preferred tool in molecular biology due to the fact that they replicate autonomously from the chromosomal DNA and that they - in other than chromosomal DNA - can be isolated from bacteria cells in intact form. They can be hydrolysed at specific recognition sequences with commercially available restriction endonucleases, joined with fragment of foreign DNA, amplified with DNA polymerases and transferred into suitable cells.

The isolation of plasmid DNA is therefore often a prerequisite for subsequent molecular biological experiments, such as PCR reactions, sequencing reactions, cloning reactions, restriction hydrolyses, transformations and transfections.



Several methods for the isolation of plasmid DNA from bacterial cells are known. Common to all these methods is that they follow the scheme:

1. Formation of cleared lysate and
2. purification of plasmid DNA from the cleared lysate.

The steps for the formation of cleared lysate are almost identical between the different methods, characteristic differences only occur during the purification of plasmid DNA from the cleared lysate.

The formation of cleared lysate comprises the steps of:

- cell lysis
- precipitation of cellular components and subsequent
- removal of the precipitate from the plasmid containing solution to form cleared lysate.

Cell lysis is usually realized under alkaline conditions in the presence of sodium dodecylsulfate resulting in bacterial crude lysate. To precipitate cellular components like chromosomal DNA, proteins, cellular debris etc., a potassium or sodium acetate buffer is added to the crude lysate, which adjusts the mixture to slightly acidic pH (4.8 to 5.0). Plasmid DNA does not precipitate under these conditions, so that it remains in the supernatant. In order to form a cleared lysate, the precipitate is removed from the plasmid containing solution either by centrifugation (Sambrook J., Fritsch E.F. and Maniatis T, (1989), "Molecular Cloning. A Laboratory Manual", pp. 7.49 to 7.50, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY Maniatis, Laboratory Manual), filtration (EP 0 616 638 B1) or magnetic separation using magnetically attractable beads which do not specifically bind the precipitate (US Patent 5,681,946 and US Patent 5,523,231).

M. A. Marko et al. discloses in "Analytical Biochemistry", Vol. 121, No. 2, April 19, 1982, pp. 382 - 387, a preparative procedure for obtaining highly purified plasmid DNA from bacterial cells. The method is adapted from an earlier procedure which gave partially purified plasmid in a form suitable for rapid screening of a large number of samples. In the method described all detectable RNA, chromosomal DNA and protein are removed without the use of enzymes phenol extraction dialysis or equilibrium centrifugation. Binding of plasmid DNA to glass powder in the presence of 6 M sodium perchlorate is used for the final purification step.

WO 95/01359 discloses a chromatographic purification and separation process for mixtures of nucleic acids. The nucleic acids to be separated and purified are adsorbed on a substrate from a solution which has a high salt concentration (ionic strength) and/or a high alcohol concentration, then desorption of the substrate is carried out by means of a solution with low salt concentration (ionic strength). The process is characterized in that the mixture of nucleic acids is adsorbed on a porous or non-porous mineral substrate made of metal oxides and/or mixed metal oxides, silica gel, materials composed mainly of glass, aluminium oxide, zeolithes, titanium dioxide, zirconium dioxide. The mixture of nucleic acids is adsorbed on the substrate from an aqueous adsorption solution with a high salt concentration (ionic strength) and with 1 to 50% by volume aliphatic alcohol with a 1 to 5 carbon atoms long chain, and/or polyethylene glycols (PEG) and/or hydrophobic, inorganic and/or organic polymers and/or organic acids, such as trichloroacetic acid (TCA). If required, the mixture of nucleic acids is then washed with a washing solution, eluted with a solution having a lower salt concentration (ionic strength) and the thus obtained nucleic acid or nucleic acid fraction is collected.

Carter, M. J., and Milton, I. D., disclose in "Nucleic Acids Research, 1993, Vol. 21, No. 4, January 11, 1993 an inexpensive and simple method for "DNA purifications on

silica particles. The method is a dissolving process concerning an already highly purified nucleic acid fraction which is bound to a matrix under non alkaline conditions.

WO-A 97/29190 discloses a scalable method for the production of highly purified plasmid DNA in *E. coli*. The method includes growing plasmid-containing cells to a high biomass in exponential growth and lysing the cells by raising the pH of the culture to a carefully controlled pH value in which chromosomal DNA is denatured but plasmid DNA is reversibly renatured. The method has been developed for the production of pharmaceutical grade DNA for use in in vivo and ex vivo gene therapy.

The methods for the purification of plasmid DNA from cleared lysate can be summarized - according to their underlying principle - into different groups.

One of these make use of density gradient centrifugation. This technique separates the components of the cleared lysate, like residual genomic DNA, RNA, proteins etc., according to their size in a caesium chloride gradient. The fraction, containing the plasmid DNA, is sucked off the centrifugational tube, further purified from salts by dialysis and finally concentrated by ethanol precipitation.

Methods of another group are based on the principle liquid-liquid extraction. The cleared lysate is several time extracted with phenol or a mixture of phenol and chloroform or a mixture of phenol, chloroform and an alcohol. During these extraction steps proteins, chromosomal DNA and other residual cellular impurities are transferred into the organic phase, while leaving the plasmid DNA in the aqueous phase. Traces from phenol were extracted several times with chloroform or a mixture of chloroform and an alcohol. The DNA is finally purified and concentrated by ethanol precipitation.

Other methods are based on anion exchange chromatography. The cleared lysate is applied on anion-exchange resin under appropriate salt and pH conditions. The binding conditions are thus adjusted that plasmid DNA are bound to the anion-exchange

material but not impurities like RNA, Proteins, residual genomic DNA. After washing out impurities under salt conditions adjusting medium ionic strength, pure plasmid DNA is eluted under high ionic strength salt conditions. To remove the salt and to concentrate the plasmid DNA a final ethanol precipitation is necessary.

Purification of plasmid DNA using silica material is another basic principle. It uses the fact that DNA adsorb to silica material in the presence of chaotropic substances. The cleared lysate is mixed with a chaotropic buffer and subsequently applied to silica material, either a silica membrane or loose silica particles. After removal of the salts by a washing step DNA is eluted with a low salt buffer or water.

All known methods for the isolation of plasmid DNA from bacteria comprise the formation of cleared lysate. All known methods for clearing the bacterial lysate after precipitation of cellular particles, centrifugation, filtration and magnetic separation using magnetically attractable beads which do not specifically bind the precipitate, display considerable disadvantages. The lysate clearing by centrifugation is usually the most time consuming step in the corresponding plasmid isolation protocols. Lysate clearing by filtration, however, requires the application of an appropriate filter, which is commonly a major cost factor of the corresponding protocol.

It is an object of this invention to provide a process for the isolation of circular nucleic acids, in particular plasmid DNA directly from sources containing such nucleic acids among other. In particular, the nucleic acids are isolated from bacterial crude lysate avoiding the need to form cleared lysate.

According to the invention a method of separating circular nucleic acids from a mixture having different species of nucleic acids other than circular nucleic acids is disclosed which avoids the drawbacks of prior art.

According to the invention, the mixture containing circular nucleic acids is treated under alkaline conditions at a  $\text{pH} > 8$  with a solid matrix consisting essentially of a silica material in presence of at least one chaotropic substance. In particular the alkaline  $\text{pH}$  can be at least 9 or about 10. The upper  $\text{pH}$  value is limited by the individual circular nucleic acid. It depends on various conditions for example on the amount and the kind of chaotropic salt present. It is in the normal skill of an artisan how to optimize the respective separation conditions in view of the technical teaching of the present invention.

Preferably, the circular nucleic acid is double stranded DNA, particularly a plasmid.

In a preferred embodiment of the present invention, the method also renders possible the separation of circular nucleic acids when the mixture contains non circular nucleic acids and at least one other species of nucleic acids, such as RNA, single stranded DNA, double stranded linear DNA or circular open double stranded DNA or even combinations thereof. In many cases, a mixture of biological origin contains the above mentioned nucleic acids. They are often present in bacterial crude lysate.

Preferably, the chaotropic substance to be used is a chaotropic salt, such as a thiocyanate salt, urea, guanidinium salt, perchlorate salt, halogenid salt. Preferred are alkali salts of the respective chaotropic anion. Also alcohols, such as methanol, ethanol, n-propanol, isopropanol n-butanol, n-pentanol or combinations can be employed as chaotropic substances according to the invention.

Preferably, the silica material is a silica or glassfiber membrane, glass or silica in particulate form such as powder, beads or frits. It may be advantageous to use a silica material which is magnetic attractable, for example magnetic attractable beads with a siliceous surface such as silica or glassfiber surfaces.

The alkaline conditions are adjusted by adding an aqueous solution of any suitable alkaline reacting substances, preferably an amphoteric substance such as an omega amino acid to the mixture containing circular nucleic acids to be separated and/or isolated. It is preferred to use an amphoteric substance having a weak acid and strong basic moiety such as  $\omega$ -amino acids. It is then possible to adjust the pH in the mixture from 8 to 12, more preferred 9 to 11, in particular about 10.

The invention is also related with an aqueous buffer comprising 6 to 9 M, preferably 7 to 8,5 M sodium thiocyanate, 0 to 20 Vol.-%, preferably 0 to 15 Vol.-% or more preferred 5 to 15 Vol.-% of C<sub>1</sub> - C<sub>4</sub> alcohols such as ethanol or isopropanol, as well as buffer substances, in particular 25 to 130 mM amino acids, preferably  $\omega$ -amino acids such as glycine. Also basic amino acids such as lysine, arginine and histidine can be used.

In the following a preferred embodiment of the present invention is described in more detail.

The present invention related to a process for the separation and/or isolation of plasmid DNA from bacterial crude lysate, eliminating the need for preparing cleared lysate by precipitating cellular components and removing the precipitate by centrifugation or filtration.

More in particular, the present invention provide methods of plasmid purification from bacterial crude lysate comprising the use of novel buffer compositions to selectively bind plasmid DNA but not chromosomal DNA or other cellular impurities from the crude lysate to silica material. The selective binding of plasmid DNA to silica material in the presence of linear chromosomal DNA fragments and other cellular impurities is achieved by adjusting alkaline binding conditions in the presence of high concentrations of chaotropic substances.

The mixture to be separated according to the invention can be obtained by a method comprising the steps of:

- cell lysis
- adjustment of appropriate conditions for selective binding of plasmid DNA preventing binding of linear DNA to silica material.
- selective adsorption of plasmid DNA to a silica surface
- washing of the silica material
- elution of the plasmid DNA from the silica material.

Preferably, the method of the invention is employed for purification of plasmid DNA from bacterial crude lysate without precipitation of cellular components and lysate clearing. The term plasmid, as used in the present specifications, means circular closed DNA molecules, either single or double stranded, which are autosomal replicable in a bacterial cell; no matter whether it is a naturally occurring plasmid or a genetically engineered.

The invention comprises the steps of:

1. lysis of bacterial cells
2. adjusting binding conditions for selective binding of plasmid DNA in the presence of linear DNA and all other cellular components
3. binding of plasmid DNA to silica material
4. washing of the silica material
5. elution of plasmid DNA.

In one embodiment of the invention the bacterial cell lysis is performed according to the traditional alkaline lysis. The bacterial cells are harvested and resuspended in low salt buffer, containing 50 mM Tris.Cl, 10 mM EDTA, pH 8.0 and 300 µg/ml RNase

A. Other species of RNase, like RNase T2, may be used but RNase A is most suitable for commercial application since it is available for a low prices. Bacterial cells are lysed after addition of an alkaline buffer containing a strong detergent. The most efficient detergent in the respect is sodium dodecylsulfate, but other detergents like Tween 20, choleic acid, deoxycholic acid and CHAPS are - to a lower amount of magnitude - suitable to lyse bacterial cells under strongly alkaline conditions. Most efficient cell lysis for the purpose of plasmid isolation is effected in a mixture with final concentration of about 100 mM sodium hydroxide and about 0.5% of sodium dodecylsulfate.

Alternatively, plasmid DNA can be purified from the "crude lysate" which can be established by a proteinase K cell-digest, or by an ultra-sonic lysis. The method of the invention is not limited to lysis of cells performed according to alkaline lysis.

The immobilization of plasmid DNA in the process according to the invention is performed by selectively and specifically bind the plasmid DNA to silica material in the presence of at least one chaotropic substance. The term specifically binding of DNA to silica material, as used in the present specifications, means that the DNA is adsorbed to the silica material and not only unspecifically attached. The term silica material, as used in the present specifications, means crystals of silicium dioxide and/or other forms of silicon oxides, such as glass powder, zeolite, no matter whether the basic solid is a membrane, resin, loose particles or magnetic beads. The term chaotropic substance, as used in the present specifications, means every substance which is able to alter the secondary and/or tertiary and/or quaternary structure of a polymer without affecting the primary structure. Examples for chaotropic substances are isothiocyanate salts, sodium iodide, sodium perchlorate, guanidinium salts, urea and short chain alcohols. Chaotropic substances are known to alter the secondary structure of polymers in general and or nucleic acids in particular. This alteration can be measured in the decrease of the melting point of double stranded DNA. All kinds of nucleic



acids, single stranded DNA, double stranded circular closed DNA, double stranded linear DNA and RNA can be immobilized on silica material under appropriated chaotropic conditions. The optimal chaotropic conditions, e.g. kind and concentration of the chaotropic substance, for the immobilization of nucleic acids to silica material vary among the different species of nucleic acids. Typical binding conditions of plasmid DNA are 2 to 4 M solutions of guanidinium hydrochloride or guanidinium thiocyanate, displaying a pH of 4 to 7. The particular optimum depends mainly on the viscosity of the mixture, the content of proteins and other substances. In general, however, under the conditions, when circular double stranded DNA is bound, linear double stranded DNA with a similar size is also bound.

Intriguingly, the chaotropic properties show some influence on the pH value which is adjusting when dissolving the chaotropic substance in water. When chaotropic substances which have a chaotropic potency are employed, a pH shift may occur. When the buffer conditions are selected for the isolation or separation of the nucleic acids according to the invention, it is advisable to check the pH adjustment when dissolving the chaotropic substance which will be employed during the operation.

Known methods for plasmid purification make use of immobilization of the plasmid DNA to silica material in the presence of chaotropic salts, the immobilization step is performed from bacterial cleared lysate. The term bacterial cleared lysate, as used in the present specifications means bacterial cell lysate, whereof cellular components are removed by precipitation and subsequent removal of the precipitate by centrifugation or filtration.

In the process for plasmid isolation according to a preferred embodiment of the invention plasmid binding to the silica material is performed starting from the crude lysate. The term bacterial crude lysate means lysed bacterial cells of which essentially no components are removed by a separation step in general respectively a precipitation step in particular. Under commonly adjusted chaotropic conditions for the bind-

ing of plasmid DNA to silica surface, present linear DNA fragments - such as sheared fragments of chromosomal DNA - are bound to the silica material additional to the plasmid DNA. Therefore, these methods require precipitation of genomic DNA and subsequent removal either by centrifugation or filtration to acquire a clean plasmid purification.

The process according to the invention renders possible to avoid the steps of precipitating cellular components, and removal of the precipitate by adjusting the chaotropic conditions in the binding mixture in a way, that substantially only plasmid DNA but not chromosomal DNA present in the mixture binds to the silica surface. This is achieved with high molar chaotropic mixtures comprising alkaline pH as binding buffer. It is known that within a certain range of pH (pH 12.0 to 12.5) plasmid DNA remains undenatured whereas chromosomal DNA is denatured (Birnboim H.C. & Doly J., (1979), "A rapid alkaline extraction procedure for screening recombinant plasmid DNA", Nucleic Acids Res 7(6), 1513 to 1523). If the pH is smaller than the lower boundary of this range, both plasmid DNA and linear chromosomal DNA fragments are undenatured, if the pH is larger than the upper boundary of this pH range both kinds of DNA are denatured. The process according to this invention takes advantage of the fact that this range of pH is shifted to lower pH values and broadened from 0.5 pH units up to more than 3 pH units in the presence of high molar chaotropic substances. The magnitude of this pH range and the absolute pH value depends on the species of chaotropic salt used and its concentration; in tendency, the higher the concentration of chaotropic salt and the stronger the chaotropic salt, the lower and broader is the pH range which causes denaturation of linear DNA but not of plasmid. Chaotropic substances in this respect are the chaotropic substances mentioned above.

Furthermore, the invention takes advantage of the effect that under the conditions - presence of high molar chaotropic substances at alkaline pH - circular closed double stranded DNA (e.g. plasmid) but not linear DNA fragments (e.g. sheared chromoso-

mal DNA) specifically binds to silica material. The precise pH may be adjusted with all kinds of pH buffers effective in this range of pH. Examples are phosphate buffers, glycine buffers and boric acid/sodium hydroxide buffer. Due to its high buffer capacity in particular glycine buffers seem to be suitable for this purpose.

Another aspect of the process according to the invention is that it affects solubilization of all the cellular components present after alkaline bacterial cell lysis. This is partially affected by the presence of high concentrations of chaotropic substances which unfold most of the present polymers, such as polysaccharides, proteins, peptides etc. It is further affected by the presence of strong detergents. The most effective surfactant in this respect is sodium dodecylsulfate, which also plays an important part during the bacterial cell lysis. Due to the heterogenous character of the cellular components which have to be solubilized, addition of a second detergent is advisable. Suitable for these purposes are members of all classes of detergents except cationic surfactants. Thus, for example anionic surfactant like choleic acid and deoxycholic acid, non-ionic surfactants like Tween 20, zwitterionic surfactants like CHAPS function well.

Summarized, the binding buffer according to the inventions allows selective binding of plasmid DNA to silica material in the presence of all cellular components including linear DNA fragments:

1. by avoiding precipitation of cellular components
2. by denaturing proteins and chromosomal DNA but not plasmid DNA
3. by adjusting chaotropic conditions which allow binding of plasmid DNA but not of linear DNA fragments in general and of sheared chromosomal DNA in particular to silica material as well as
4. by solubilizing the cellular components to a homogenous mixture.

Immobilization of nucleic acid such as DNA is performed by adsorption of the nucleic acid to silica material in the presence of high salt; which is well known in the field of

molecular biology for nearly 20 years (Vogelstein B. & Gillespie D., (1979), "Preparative and analytical purification of DNA from agarose", Proc. Natl. Acad. Sci. 76(2): 615 to 619).

Several kinds of silica material have been tested according to the present invention: magnetic silica particles, loose silica particles and silica membranes.

Washing of the silica material after the binding step is preferred. On the one hand, impurities arising from the biological sample, which are present at the silica material after the binding step, and on the other hand the chaotropic substances applied in the binding, which are partially attached to the silica material. Both should be removed from the silica material.

The removal of these impurities is not only recommendable in the process according to the present invention but in all known processes preferably for DNA purification using silica material.

Impurities arising from the biological sample after the binding step on the silica surface are mainly due to two reasons.

Substantially all silica materials provide a certain death volume, depending on the kind of silica material and the amount of silica material applied for e.g. DNA purification. Preferably, the death volume should not exceed about 50  $\mu$ l. The death volume of silica material provided in commercially available kits for purification of up to 20  $\mu$ g plasmid DNA from a 5 ml bacterial overnight culture lies in the range of 2 to 5  $\mu$ l. Death volume in this context means the difference of the wet to the dry volume of the silica material. The death volume after each purification step consists of the buffer applied in this step. Thus, after the binding step, the death volume of the silica material consists of the binding mixture, containing all cellular components.

In the process according to the invention these impurities are substantially removed by the application of a washing buffer, containing high amounts of a chaotropic substance at alkaline pH. The chaotropic substance solubilizes the impurities and removes them from the silica membrane. The alkaline pH is preferred to prevent binding of the denatured chromosomal DNA to the silica material. The adjustment of the appropriate pH is accomplished with the pH-buffers mentioned for the binding buffer.

Basically, the washing buffer according to the process of this invention works in an analogous way as the binding buffer. Since e.g. DNA, specifically bound to silica material, display slightly different characteristics according to chaotropic buffers, the washing buffer must display a slightly different composition as the binding mixture. Preferably, the washing buffer comprises in particular short chain aliphatic alcohols such as isopropanol or ethanol in the range of 5 to 40 vol-%, preferably of 20 to 40 vol-% final concentration. Since short chain alcohols are itself chaotropic, it is tolerable that the concentration of chaotropic salts is slightly lower in the appropriate washing buffer than in the corresponding binding buffer. Typical concentration - depending of the kind of chaotropic salt used - are within the range of 4 to 9, preferably of 4 to 6 molar.

Alternatively, also neutral or moderate acidic washing buffers can be used. A neutral or acidic chaotropic buffer contains 1,5 - 3 M chaotropic salt in presence of 10 - 30% ethanol or isopropanol as for adjusting the pH up to about 4.

After washing out the impurities from the biological sample, the chaotropic salts have to be removed from the silica material. This is done with one or more washing steps with an alcohol or water solution. Typically ethanol (preferably about 80%) is used, but other short chain alcohols work as well.

Elution of plasmid DNA is performed either with pure water or with low salt buffers.

The process of the invention can easily be performed by the customer when the materials used in the process are provided in form of a kit. Therefore, also a kit is subject of the present invention which comprises an aqueous buffer comprising 6 to 9 M preferably 7 – 8,5 M sodium thiocyanate, 0 to 20 vol.-% 0 to 15 vol.-% or more preferred 5 to 15 Vol.-% of C<sub>1</sub> - C<sub>4</sub> alcohols such as ethanol or isopropanol, 25 to 130 mM buffer substances in particular amino acids preferably  $\omega$ -amino acids such as glycine. The kit according to the invention may further contain auxiliary materials such as columns with or without siliceous material, siliceous material in suspension form, further buffers and instruction manuals. Further buffers are preferably those which are used in the process of the invention as, for example, resuspension buffer, lysis buffer, washing buffer, elution buffers and the like. Also spin columns may be incorporated in the respective kit. The configuration of such kit is in particular corresponding to the protocol to be followed by the customer.

Typical protocols are further explained in the following examples.

## Examples

### Buffer compositions

Resuspension Buffer (P1):	50 mM Tris.Cl, 10 mM EDTA, pH 8.0; 300 µg/ml RNase A
Lysis Buffer (P2):	100 mM NaOH, 0.1% SDS
Binding Buffer (PB):	7.6 M NaSCN, 10% EtOH (v/v), 5% Tween 20; 60 mM glycine, pH 9.6 or 8.2 NaSCN, 10% ethanol (v/v), 5% Tween 20, 60 mM glycine, pH 9.6

Washing Buffer (PW1): 5.5 M NaSCN, 30% EtOH, 100 mM Glycine pH 9.6 or

1.5 M GuHCl, 30 % (v/v) Isopropanol, 150 Kaliumacetat, pH 5,1

Washing Buffer (PW2): 80% EtOH, 10 mM Tris.Cl, pH 7.5

Elution Buffer (PE): 10 mM Tris.Cl, pH 8.5

#### Silica materials

Spin columns containing silica-gel membranes supplied by Qiagen GmbH, Hilden, Germany which may comprise stacks of several membrane layers.

Silica resin suspension: commercially available QIAEX II gel extraction kit supplied by Qiagen GmbH, Hilden, Germany

Magnetic silica beads, AGOWAmag®, AGOWA, Germany.

#### Protocol A -

This protocol is suitable for isolation of up to 10 µg of plasmid DNA from bacterial overnight cultures of up to 1.5 ml. The procedure uses spin columns containing silica-gel membranes, and all steps are performed at maximum speed ( $\geq 10,000 \times g$  or 13,000 rpm) in a conventional table-top microcentrifuge unless otherwise stated.

Advantageously, the process of the invention can be performed in multi well plates having 96 wells, 384 wells or even more wells. Due to this, the process of the inven-

tion may be employed with automatic pipetting machines, e. g. the BioRobot® of Qiagen®, Hilden, Germany.

1. Harvest an appropriate volume of bacterial overnight culture in a microcentrifuge at 5.000 x g.
2. Resuspend pelleted bacterial cells in 100 µl of Buffer P1.
3. Add 100 µl of Buffer P2, mix the sample by vortexing, and incubate at room temperature for 5 min.
4. Add 500 µl of Buffer PB and mix thoroughly by vortexing vigorously.
5. Place a spin column in a microcentrifuge tube, and apply the sample to the spin column.
6. Centrifuge for 1 min and discard the flow-through.
7. To wash, add 500 µl of Buffer PW1 to the spin column, centrifuge for 1 min and discard the flow-through.
8. To wash, add 750 µl of Buffer PW2 to the spin column, centrifuge for 1 min and discard the flow-through.
9. Centrifuge for an additional 1 min to remove residual washing buffer.
10. Transfer the spin column into a clean microreaction tube. To elute DNA, add 50 µl of Buffer PE to the center of each spin column, let stand for 1 min, and centrifuge for 1 min.



Protocol B

This protocol is suitable for isolation of up to 10 µg plasmid DNA from bacterial overnight cultures of up to 1.5 ml. The procedure uses QIAEX II silica particles, and all steps are performed in microcentrifuge tubes. Centrifugation steps are carried out at maximum speed ( $\geq 10,000 \times g$  or 13,000 rpm) in a conventional table-top microcentrifuge unless otherwise stated.

1. Harvest an appropriate volume of bacterial overnight culture in a microcentrifuge at  $5,000 \times g$ .
2. Resuspend pelleted bacterial cells in 100 µl of Buffer P1.
3. Add 100 µl of Buffer P2, mix the sample by vortexing and incubate at RT for 5 min.
4. Add 500 µl of Buffer PB.
5. Resuspended QIAEX II by vortexing for 30 sec. Add 25 µl of QIAEX II to the sample and mix thoroughly by vortexing vigorously.
6. Incubate at room temperature for 5 min, then centrifuge for 30 sec at  $> 10,000 \times g$  and remove discard the supernatant with a pipet.
7. Wash the pellet with 750 µl of Buffer PW1, resuspending the pellet by vortexing, and centrifuging for 30 sec. Remove all traces of supernatant.
8. Wash the pellet twice with 750 µl of Buffer PW2, resuspending the sample for 30 sec. Remove all traces of supernatant.

9. Air-dry the pellet at room temperature for 20 min.
10. To elute, add 60  $\mu$ l of Buffer PE and resuspend the pellet by vortexing, Incubate at room temperature for 5 min.
11. Centrifuge for 30 sec. Carefully pipet the supernatant into a clean tube.
12. Optional: repeat steps 10 and 11 and combine the eluates.

### Protocol C

This protocol is suitable for parallel isolation of up to 10  $\mu$ g plasmid DNA from 96 bacterial overnight cultures. The procedure uses magnetic silica particles, and all steps are performed in 96-well microtiter plate format. For steps requiring repeated pipetting, a reservoir or multichannel pipet can greatly facilitate liquid handling.

1. Harvest appropriate volumes of bacterial overnight culture at 5.000 x g.
2. Resuspend the pelleted bacterial cells in 100  $\mu$ l of Buffer P1 and transfer the samples to the well of a 96-well round-well block.
3. Add 100  $\mu$ l of Buffer P2 to each well. Mix thoroughly by vortexing the block and incubate at room temperature for 5 min.
4. Mix 50 ml of Buffer PB and 2 ml of magnetic silica suspension in a plastic beaker. Add 520  $\mu$ l of this suspension to each well of the round-well block.
5. Seal the block with adhesive tape and mix thoroughly by shaking the block vigorously. Incubate on a shaker at room temperature for 5 min.

6. Place the block into a magnetic separator, remove the tape, and let stand for 1 min. Discard the supernatants.
7. Remove the block from the magnetic separator. Add 750  $\mu$ l of Buffer PW 1 to each well. Seal the block with adhesive tape and mix thoroughly by shaking the block vigorously.
8. Place the block back into the magnetic separator, remove the tape, and let stand for 1 min. Discard the supernatants.
9. Remove the block from the magnetic separator. Add 750  $\mu$ l of Buffer PW2 to each well. Seal the block with adhesive tape and mix thoroughly by shaking the block vigorously.
10. Place the block back into the magnetic separator, remove the tape, and let stand for 1 min. Discard the supernatants.
11. Repeat steps 9, 10, but discard only 600  $\mu$ l of each supernatant.
12. Remove the block from the magnetic separator, and resuspend the magnetic particles in the residual supernatant by vortexing. Transfer the sample to the wells of a 96-well microtiter plate. Place the microtiter plate into the magnetic separator, let stand for 1 min and remove the residual supernatant.
13. Air-dry the microtiter plate at room temperature for 20 min.
14. To elute DNA, add 60  $\mu$ l of Buffer PE to each well, resuspend the pellets, and incubate the microplate on a shaker for 5 min.

15. Place the microplate into the magnetic separator and let stand for 1 min. Transfer the supernatants into a clean 96-well microtiter plate.
16. Optional: repeat steps 14 and 15 and combine the eluates.

### Example 1

#### *Specific binding of circular plasmid DNA to silica material in the presence of linear DNA*

This example demonstrates the property of the binding buffer according to this invention to selectively bind double stranded circular closed DNA to silica material in the presence of double stranded linear DNA.

500 ng of pUC19 plasmid DNA were spiked with total 1 µg of double stranded linear DNA fragments within a size range of 150 bp to 20 kb, which were produced by an enzymatic hydrolysis of lambda phage DNA with the restriction endonucleases *Hind* III and *Eco* RI. This DNA mixture was purified according to protocol A and protocol C with slight modifications. They were performed using the buffers describes above, with the modification of adding the DNA mixture to 100 µl of buffer P1 and omit the application of bacterial cells. Additionally, the purification according to each of the two protocols were performed with two modified binding buffers, one consisting of 4 M potassium thiocyanate, 30% isopropanol and 10 mM Tris.Cl adjusted to a pH of 7.0 (Buffer C2) and another consisting of 8.8 M sodium Thiocyanate, 10% EtOH, 10 mM Tris.Cl adjusted to a pH of 7.0 (Buffer C3).

The eluates contains pure plasmid DNA without traces of linear DNA if alkaline binding buffer is used. If modified binding buffers with neutral pH instead of alkaline

pH is used, a mixture consisting of linear DNA fragment and plasmid DNA were obtained.

This experiment clearly shows that only the combination of a chaotropic salt and an alkaline pH in the binding mixture allows selective binding of the circular plasmid but not of linear DNA.

## **Example 2**

### *Determination of pH range allowing selective binding of plasmid DNA*

This example determines the pH range where selective binding of plasmid DNA from a mixture of plasmid DNA and sheared genomic DNA fragment is possible. Genomic DNA was prepared from *Escherichia coli* using the silica membranes like membranes as QIAamp Tissue Kit (QIAGEN) (Molecular cloning (1)). 2 µg of genomic DNA were mixed with 2 µg of pUC19 plasmid DNA and purified according to protocol C (with the modification of adding the DNA mixture to 100 µl of buffer P1 and omit the application of bacterial cells) with a modified binding buffer. The binding buffer consist of 4 M potassium thiocyanate, 0,6 M sodium chloride, 0,1 M glycine and 30% ethanol adjusted so that the pH in the binding mixture is between 11.1 and 12.4.

At a pH value of 11.1 small traces of genomic DNA were copurified indicating the that separation between plasmid and genomic DNA is incomplete at his pH. Within a range of pH from 11.25 to 12.0 plasmid DNA is selectively purified free from impurities of genomic DNA. For a pH above 12.0 neither plasmid nor genomic DNA could be obtained.

The same experiment was performed with a more chaotropic binding buffer, consisting of 8.8 M sodium thiocyanate. In this case, complete separation of plasmid and genomic DNA could be achieved within a pH range of 9.2 to 11.1.

### Example 3

#### *Specific removal of linear DNA from mixture of linear DNA and plasmid DNA bound to silica material*

This example demonstrate that linear DNA, once bound to silica material, can be selectively washed away with a chaotropic buffer at alkaline pH. Two mixture consisting of 1 µg plasmid DNA and total 2 µg of double stranded linear DNA fragments within a size range of 150 bp to 20 kb, which were produced as described in example 1, were bound with a modified binding buffer - consisting of 4 M potassium isothiocyanate and 30% ethanol - to the silica membrane of two QIAamp spin column (QIAGEN) according to protocol A (steps 1 to 5, with the modification of adding the DNA mixture to 100 µl of buffer P1 and omit the application of bacterial cells). The modified binding buffer was known (see example 2) to bind both, plasmid and genomic DNA to silica membranes.

The residual steps of protocol A (steps 6 to 9) were performed by using the washing buffer W1 (5.5 M NaSCN, 30% EtOH, 100 mM glycine, pH 9.6) for one spin column and by using a modified washing buffer PWC (containing 5 M guanidine hydrochloride, 30% isopropanol and 10 mM tris.Cl adjusted to a pH of 7.0).

When the chaotropic washing buffer adjusted to an alkaline pH (washing buffer W1) was used, plasmid DNA pure rid from linear DNA could be obtained. However, when using a comparable chaotropic washing buffer which was adjusted to neutral pH (buffer PWC), a mixture of plasmid and linear DNA was purified.

This experiment show that a chaotropic buffer comprising alkaline pH is able to selectively remove linear DNA from a mixture of circular closed and linear DNA by not affecting the binding of circular closed DNA.

**Example 4***Isolation of plasmid DNA from Escherichia coli using silica membranes*

This example describes the standard plasmid isolation procedure according to this invention using a silica membrane.

1.5 ml overnight cultures of several *Escherichia coli* strains containing plasmids were purified according to protocol A. Between 2 and 5 µg of pure plasmid DNA were obtained from each sample.

**Example 5***Isolation of plasmid DNA from Escherichia coli using loose silica resin*

This example describes the standard plasmid isolation procedures according to this invention using a loose silica particles.

1.5 ml overnight cultures of several *Escherichia coli* strains containing plasmids were purified according to protocol B. QIAEX II particles were used as silica particles. Between 2 and 5 µg of pure plasmid DNA were obtained from each sample.

**Example 6***Isolation of plasmid DNA from Escherichia coli using magnetic silica particles*

1.5 ml overnight cultures of several *Escherichia coli* strains containing plasmids were purified according to protocol C. Magnetic beads from QIAGEN were in this experiment. Between 2 and 5 µg of pure plasmid DNA were obtained from each sample.

### Claims

1. A method for separating and/or isolating circular nucleic acids from a mixture having different species of nucleic acids other than circular nucleic acids wherein the mixture is treated under alkaline conditions at a pH > 8 with a solid matrix consisting essentially of a silica material in presence of at least one chaotropic substance.
2. The method of claim 1, wherein the circular nucleic acid is double stranded DNA, in particular a plasmid.
3. The method of claim 1 and/or 2, wherein the mixture contains non circular nucleic acids and at least one other species of nucleic acids, such as RNA, single stranded DNA, double stranded linear DNA or circular open double stranded DNA or combinations thereof.
4. The method of any one of the claims 1 to 3, wherein the mixture is of biological origin, such as bacterial crude lysate.
5. The method of any one of the claims 1 to 4, wherein the chaotropic substance is a chaotropic salt, such as a thiocyanate, urea, guanidinium salt, perchlorate salt, a halide salt and/or the chaotropic substance is an alcohol, such as methanol, ethanol, n-propanol, isopropanol, n-butanol, n-pentanol or combinations of said chaotropic substances.
6. The method of any one of the claims 1 to 5, wherein the silica material is a silica or glassfiber membrane, glass or silica in particulate form such as powder, beads or frits and/or silica-gel membranes comprising stacks of several membrane layers (multi layer membranes).



7. The method of any one of the claims 1 to 6, wherein the silica material is magnetic attractable beads with a siliceous surface such as silica or glassfiber surface.
8. The method of any one of the claims 1 to 7, wherein the alkaline conditions are adjusted by adding an aqueous solution of an amphoteric substance such as an omega amino acid to adjust in particular a pH of 8 to 12 in the resulting mixture.
9. The method of any one of the claims 1 to 8, performed in multi well plates such as 384 or 96 wells.
10. The method of any one of the claims 1 to 9, performed in an automated manner.
11. The method of any one of the claims 1 to 10, wherein the following process steps are performed:
  - cell lysis
  - adjustment of appropriate conditions for selective binding of plasmid DNA preventing binding of linear DNA to silica material
  - selective adsorption of plasmid DNA to a silica surface
  - washing of the silica material
  - elution of the plasmid DNA from the silica material.
12. An aqueous buffer comprising 6 to 9 M sodium thiocyanate, 0 to 20 Vol.-% C<sub>1</sub> - C<sub>4</sub> alcohols such as ethanol or isopropanol, 25 to 130 mM buffer substance preferably ω-amino acids.

13. A kit comprising the aqueous buffer of claim 12 and auxiliary materials such as columns with or without siliceous material, suspensions of siliceous material, additional buffers such as resuspension buffers, lysis buffers, washing buffers, elution buffers, instruction manual.

**Abstract**

A method for separating and/or isolating circular nucleic acids from a mixture having different species of nucleic acids other than circular nucleic acids wherein the mixture is treated under alkaline conditions at a  $\text{pH} > 8$  with a solid matrix consisting essentially of a silica material in presence of at least one chaotropic substance.

## PATENT COOPERATION TREATY

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## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 990605woMegn	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP99/03660	International filing date (day/month/year) 27/05/1999	Priority date (day/month/year) 27/05/1998
International Patent Classification (IPC) or national classification and IPC C12N15/10		
Applicant QIAGEN GMBH		

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1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.


2. This REPORT consists of a total of 5 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 25/11/1999	Date of completion of this report 05.09.2000
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Hillenbrand, G Telephone No. +49 89 2399 8428



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/EP99/03660

**I. Basis of the report**

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

**Description, pages:**

1-24 as originally filed

**Claims, No.:**

1-13 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:  
☐ the claims, Nos.:  
☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes:	Claims	1-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-11
	No:	Claims	12-13
Industrial applicability (IA)	Yes:	Claims	1-13
	No:	Claims	

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/EP99/03660

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2. Citations and explanations

**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/EP99/03660

- D1: WO 95 01359 A (QIAGEN GMBH ;COLPAN METIN (DE); SCHORR JOACHIM (DE); HERMANN RALF) 12 January 1995 (1995-01-12)
- D2: CARTER M J ET AL: 'AN INEXPENSIVE AND SIMPLE METHOD FOR DNA PURIFICATIONS ON SILICA PARTICLES' NUCLEIC ACIDS RESEARCH, vol. 21, no. 4, 1 January 1993 (1993-01-01), page 1044 XP002001949
- D3: MARKO M A ET AL: 'A PROCEDURE FOR THE LARGE-SCALE ISOLATION OF HIGHLY PURIFIED PLASMID DNA USING ALKALINE EXTRACTION AND BINDING TO GLASS POWDER' ANALYTICAL BIOCHEMISTRY, vol. 121, no. 2, April 1982 (1982-04), pages 382-387, XP000602405

**Re Item V**

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Favourable consideration is given to the arguments of the applicant with respect to novelty and inventive activity involved with the matter claimed in Claims 1-11. The present invention provides a method in which the neutralization step and the centrifugation step described in the prior art as reflected by the documents cited above can be omitted, and in which the binding step can be performed from a mixture of various components under alkaline conditions. Consequently, the time required for the separation or isolation of circular nucleic acids can be reduced.

Thus, novelty and the inventive step involved with the subject-matter of Claims 1-11 can be acknowledged.

**Inventive step (Article 33.3 PCT) of Claims 12-13**

The subject-matter of Claims 12-13 is considered novel but lacks the required inventive step. In the absence of any data suitable to demonstrate an unexpected/advantageous technical effect involved with the aqueous buffer/kit itself, the required inventive step can not be acknowledged.

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/EP99/03660

**Re Item VIII**

Certain observations on the international application

The subject-matter of Claim 13 does not comply with the requirements of Article 6 PCT. The features mentioned in said claim are too broadly and imprecisely drafted and because it is not visible which defined materials are indeed embraced by the terms "columns, additional buffers, resuspension buffers, lysis buffers, washing buffers, elution buffers and instruction manual (for what?)". In order to overcome this objection it is proposed either to more precisely define the claimed matter or to delete said claim.

Finally, the attention of the applicant is drawn to the fact that the subject-matter of Claim 12 should be referred back to at least one of the process claims (if there is an original disclosure for such a combination) in order to avoid a possible lack of unity objection under Rule 13 PCT. According to Rule 13 PCT the claims should contain technical features which are capable to link process claims with product claims in order to establish a single general inventive concept.

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